INJURY-PRODUCING EVENTS AMONG CHILDREN IN LOW-INCOME COMMUNITIES: THE ROLE OF COMMUNITY CHARACTERISTICS

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ABSTRACT

Study Purpose. Injury remains the leading cause of death in children aged 1 to 4 years. Past studies of determinants of injuries among young children have most often focused on the microlevel, examining characteristics of the child, parent, family, and home environments. We sought to determine whether and how selected neighborhood economic and physical characteristics within these low-income communities are related to differences in risk of events with injury-producing potential among infants and young children.

Methods. Our study used both individual-level data and information on the characteristics of the neighborhood of residence to describe the prevalence of events with injury-producing potential among infants and young children in three low-income communities in Baltimore City, Maryland. Our sample was 288 respondents who participated in a random household survey. Information on respondent (age, employment, and length of residence in the neighborhood) and neighborhood characteristics (average per capita income, rate of housing violations, and crime rate) were available. Methods of multilevel Poisson regression analysis were employed to identify which of these characteristics were associated with increased risk of experiencing an event with injury-producing potential in the month prior to the interview.

Results. Although all three communities were considered low income, considerable variation in neighborhood characteristics and 1-month prevalence rates of events with injury-producing potential were observed. Younger age of respondent and higher rates of housing violations were associated significantly with increased risk of a child under 5 years old in the household experiencing an event with injury-producing potential.

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Conclusions. Information on community characteristics was important to understanding the risks for injuries and could be used to develop community-based prevention interventions.

INTRODUCTION

Injury remains the leading cause of death in children aged 1 through 4 years, and injury death rates for infants younger than 1 year are more than twice that for older children.[1,2] One-fourth of all emergency room visits are for an injury among children younger than 5 years old, and many of these injuries occur in and around the home, most commonly due to falls.[3]

Estimating the true risk of injury is challenging because injury assessment across studies is often based on different sources of data. Estimates of injury incidence from hospitalization or emergency room records are only based on injuries that are attended medically; children who are not seen by a health care provider due to issues of severity, access, or expense are omitted from such estimates. Obtaining information about the true extent of the injury problem, particularly in low-income communities in which injuries may be less likely to be attended medically due to differentials in access to care, presents an important methodological challenge for injury researchers. The occurrence of events with the potential for causing injury (e.g., falls, having access to dangerous items) represents a measure of children's exposure to injury risk and therefore is an appropriate substrate for prevention. However, information on prevalence of events with injury-producing potential is rarely available from surveys or other routinely collected data sources.

Studies of determinants of injury risk among young children have focused most often on the individual or microlevels, examining characteristics of the child and family[4,5] or housing and home environments.[6] However, the importance of macrolevel contextual factors in influencing individual behaviors and health outcomes is being recognized increasingly in the public health and social science literature.[7-10] Contextual effects may be especially important to consider when examining child health issues such as injury since the safety of infants and young children is dependent at least partially on the environment in which they grow and develop.[2,11]

Past studies of environmental determinants of injury in children[6,12-14] have limited their examination to the physical hazards that produce injury (e.g., unfenced pools, lack of child-resistant packaging) or the social environment that protects individuals through legislation and regulation (e.g., seat belt laws, toy safety standards).[15] When characteristics of the environment are considered in injury control, macrolevel social conditions typically were not included until recently. A study in the United Kingdom[16] found that both the individual-level family characteristics and a neighborhood-level measure of social deprivation contributed to the risk of being injured among preschool age children. To add to this literature and to enrich our understanding of how to best target risk reduction efforts for behavioral and environmental determinants of injury, a contextual analysis of community- and individual-level risk factors using appropriate statistical methods would be useful.

As part of a larger study on the association of community characteristics with health outcomes, we collected information on events with the potential to produce injury in households with young children in three low-income urban neighborhoods in Baltimore City, Maryland. Our specific research objectives were

1. To describe the prevalence of events with injury-producing potential among households with infants and young children in three low-income communities in Baltimore City.
2. To determine whether and how selected neighborhood economic and physical characteristics within these low-income communities were related to differences in risk of events with injury-producing potential among households with infants and young children.
3. To assess whether neighborhood economic and physical characteristics modify the relationship between individual risk factors and selected events with injury-producing potential.

METHODS

DATA COLLECTION

A household survey was conducted in three communities (clusters of census tracts) in Baltimore City in 1994. This survey was part of a local evaluation effort for a nationwide community-based infant mortality reduction demonstration project called Healthy Start. Baltimore City was 1 of 15 US sites chosen for this demonstration project, which began in late 1991.

The random household survey was conducted between May and July 1994. Interviews were conducted by persons hired from the three communities; they received special training for the survey. Households in the three communities were sampled using the following procedures. A complete list of hundred blocks within each of the three communities was obtained; within each community, 80 hundred blocks were selected randomly. For each block, a house was chosen randomly and approached for possible participation. Every third house after the first house was approached for participation until members of four households were interviewed on that block. Chosen blocks that were found subsequently to be nonresidential (e.g., business sites, vacant lots or parks, or industrial settings) were replaced with blocks newly chosen at random. This process was followed until 300 interviews per community were completed. Interviewers were allowed to return to the blocks three times to complete four interviews. Respondents had to be between the ages of 18 and 65 and were chosen from among the adults at home by a preset criterion each day (e.g., oldest adult home, second to the youngest adult home). There were 894 completed, of which 288 were from homes with children younger than 5 years.

Assessment of Events with Injury-Producing Potential

As part of the survey, a set of questions related to childhood injuries was asked of respondents from households that had a child under the age of 5. There were 12 questions related to events with potential to produce injury; the time frame for purposes of the survey was the past month. For each of the 12 outcomes, the respondent was asked whether such an event had occurred to a child within the household and, if so, the age of the child involved. If there was more than one child in the household who experienced the event, we only recorded information on the youngest child. The respondents were asked: Has a child in this household under the age of 5 in the past month

1. Fallen down the stairs?
2. Fallen from a bike, tricycle, or other toy?
3. Fallen from a piece of furniture?
4. Nearly gotten burned?
5. Gotten hold of something you thought might be poisonous?
6. Gotten hold of something you thought might be dangerous?
7. Choked on something?
8. Done something that you thought was dangerous?
9. Fallen out a window?
10. Nearly been hit by a car or truck?
11. Been in a car accident?
12. Nearly drowned?

These 12 events were selected because they reflect the typical scenarios associated with the most common serious injuries in the preschool-aged population and because effective prevention strategies exist. Furthermore, we sought to gain comprehensive information about events with injury-producing potential that could occur in the home or outside the home (e.g., falling down stairs, being nearly hit by a car, falling from a bike) as community approaches to reducing injury should focus on both areas. No assumption or inference was made regarding whether the event actually led to bodily damage constituting an injury. A child could be exposed to all 12 events without incurring an injury or be exposed to 1 event that led to serious injury. The aim of the questions was to assess the frequency of hazardous, potentially injurious events in the community.

The Dependent Variable: Frequency of Events with Injury-Producing Potential

A variable was created that summarized the number of these events that occurred, a count between 0 and 12. Because the survey was constructed to determine if any child in the household had experienced an event, households with more children potentially would have higher average numbers of incidents. In the case of the 54 households (19%) in which more than one child experienced an event, the summary of events was reduced to include either the child with the greatest number of reported injury events or, if there were two or more children with the same number of events, the youngest child. Although this has the potential to overestimate the prevalence of events, the bias is minimal (see Results section).

Individual-Level Independent Variables

There were four demographic characteristics of the adult/parent respondent available from the survey that were used in the present analysis: employment status (not employed vs. employed part or full time); age (categorized into intervals); gender; and length of residence in the neighborhood (<1 year, 1–2 years, 3–5 years, 6–10 years, >10 years).

Neighborhood-Level Independent Variables

Eighteen census tracts, referred to here as "neighborhoods," comprised these three communities. Three indicators regarding the conditions of each census tract were included to illustrate the effect of "context" on individuals: annual per capita income, annual rate of housing violations, and annual crime rate. The number of housing violations served as a proxy for risk of injury due to the quality of structures and buildings in the community. High rates of housing violations may have a direct impact on the risk of injury. Crime rates in low-income neighborhoods can serve as a proxy for levels of social breakdown and disorganization. Such neighborhoods may have less monitoring and greater risks for injuries for children (e.g., no safe play areas).

Although these were all low-income neighborhoods, there was enough variability in per capita income by neighborhood to investigate the possibility of variation in injury-producing events by income levels. Lower income neighborhoods, as with more disorganized neighborhoods, may have fewer safe places for children to gather and play. These indicators were created by obtaining information on the numerators (e.g., number of property or personal crimes and housing violations in a neighborhood) and denominators (e.g., households or persons in a neighborhood) and calculating simple rates. Housing violations, structural problems, and the presence of lead are recorded routinely by city government when housing inspections are conducted. Housing inspections are conducted when homes are being sold, because of a request by tenants, and for a random sample of houses in the city each year. Per capita crime rates were based on 1992 crimes reported to the police department, including robbery (both armed and unarmed), homicide, theft, burglary, rape, and aggravated assault. These neighborhood descriptors can be thought of as facets of the context in which the children live. Other data on neighborhood characteristics were obtained from a commercial source of census tract information, Claritas NPDC (Ithaca, NY), and based on the 1990 census.

Statistical Methods

To answer the first research question, descriptive statistics were calculated on the individuals in our study and on the neighborhoods, including the prevalence of injury-producing events in the three communities. The variation in prevalence of the injury-producing events across neighborhoods then was examined. This not only gave us information about the heterogeneity of low-income communities with respect to neighborhood economic and social organizational factors and injury risk, but also helped us to determine which variables to include in our multilevel analysis. The final phase of statistical analysis was to conduct multilevel Poisson regression modeling. Using this statistical method, we examined whether neighborhood factors were associated directly with events with injury-producing potential, as well as any modifying effects that neighborhood characteristics may have on individual-level factors and outcomes (i.e., cross-level interactions between neighborhood- and individual-level variables). Multilevel Poisson regression analysis was performed using the statistical software package MLn.[17] This software package allows the analysis of any number of levels of data. Use of MLn, or a similar package that accommodates multiple levels of data, was necessary to account for the multiple sources of random components of the model. The rationale and method are described in greater detail in the Appendix.

RESULTS

Individual and Neighborhood Characteristics

Table I summarizes selected characteristics of the individuals and neighborhoods included in this study. Of the 896 households surveyed, 288 (32%) had a young child under the age of 5 living in the home and supplied the data for our analyses. In regard to individual-level characteristics, a majority of respondents to this survey were employed and female. Approximately half were younger than 30 years. There was a relatively equal distribution in length of residence. Neighborhoods in this study, which were all economically poor, showed considerable variation in their average per capita income, in addition to variation in housing and crime indicators (see Table II). Interestingly, neither the housing nor crime indicators shows a consistent relationship to income.

Events with Injury-Producing Potential

The overall prevalence of the injury-producing events in 1 month is summarized in Table III. Falls from various sources represented the most frequent occurrences, while being hit by a car, being involved in a motor vehicle crash, falling from a

Table I Characteristics of Respondents and Neighborhoods

Individual-Level Characteristics (n = 288)	Percentage	
Employed part- or full-time	54	
Age of respondent		
18–20 years	6	
20–29 years	41	
30–39	42	
40–49	12	
50–65	9	
Gender of respondent		
Male	27	
Female	73	
Length of residence		
Less than 2 years	26	
3–5 years	26	
6–10 years	20	
More than 10 years	28	
Neighborhood-Level Characteristics (n = 18)	**Mean**	**SD**
Number of households in census tract in 1994	1,459	369
Per capita income (rounded)	$8,800	$1,900
Rate of housing violations (per 100 households)	6.24	5.42
Crime rate, property plus personal (per 100 persons)	16.80	4.60

TABLE II Characteristics of Study Neighborhoods that Indicate Heterogeneity Among Urban Low-Income Communities

Census Tract	Number of Households	Number of Surveys	Per Capita Income, 1994	Housing Violations	Crime Rate
A	1,518	12	6.00	2.70	16.05
B	1,441	11	6.10	6.04	20.84
C	1,239	10	6.16	5.25	26.74
D	1,024	18	7.39	6.64	24.91
E	1,117	12	7.46	4.03	15.09
F	1,511	25	7.69	19.13	14.14
G	2,054	27	8.04	1.51	10.27
H	2,114	18	8.45	2.65	15.73
I	1,014	6	8.48	2.56	14.93
J	1,738	22	8.79	9.26	13.79
K	2,166	17	8.87	4.80	10.78
L	1,383	25	9.03	7.88	16.15
M	1,314	10	9.04	0.23	11.48
N	1,144	12	9.82	7.52	15.54
O	1,012	14	10.49	3.36	16.80
P	1,623	20	11.46	8.26	17.78
Q	1,560	13	12.18	1.03	23.36
R	1,296	16	12.27	19.44	18.08

Census tracts are arranged from lowest to highest income.
Per capita income expressed in thousands of dollars.
Housing violations is number of violations per 100 households.
Crime rate is number of total crimes (personal + property) per 100 individuals.

window, and nearly drowning were all the least frequent. As these numbers may be inflated by multiple children per household, the prevalence of events including only 1 child per household is noted in Table III. The remainder of the analyses involve figures for 1 child per household. The 1-month prevalence of the injury events across census tracts is illustrated in the Figure. The ranges of prevalence rates for each injury presented in the Figure are based on the data with 1 child per household. While some events, such as falling from a bicycle or toy, consistently are frequent from neighborhood to neighborhood; other events, such as falling down stairs, show wide differences. In addition, the most commonly occurring injury-producing event varies across census tracts. In some census tracts, falling down stairs is the most common event, while in others, falling from a bike/toy or falling from furniture is most common (data not shown).

The frequency of events with injury-producing potential across households is presented in Table IV. None of the 12 injury-producing events were experienced

TABLE III Prevalence of Events with Injury-Producing Potential Among All Children in Households and After Limiting Analysis to One Child per Household (n = 288)

Outcome	Percentage of Households Including All Children	Percentage of Households After Limiting to One Child
Fall from furniture	41	36
Fall from bike or toy	40	34
Fall down stairs	22	19
Got hold of something dangerous	19	18
Did something dangerous	18	15
Nearly choked	14	13
Got hold of something poisonous	11	10
Nearly burned	8	7
Pedestrian injury (hit by car)	1	1
Motor vehicle crash	1	1
Fall from window	1	1
Nearly drowned	1	1

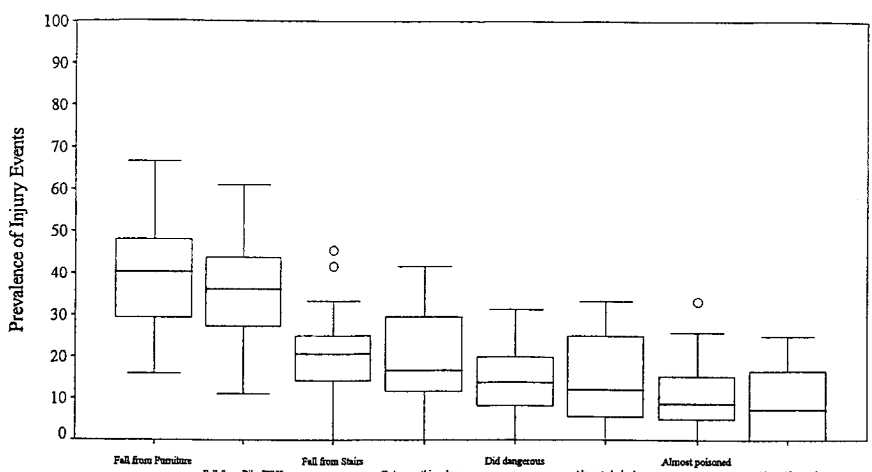

FIGURE 1 Prevalence of injury producing events across census tracts. The range of injury producing events across census tracts are indicated by the bars. The average number of injury producing events across all census tracts is indicated by the line within the box and the box indicates the standard deviation.

TABLE IV Frequency of Injury Events Across Households (n = 288)

Number of Events (of 12 Possible)	Percentage of Households
None	35.8
1	23.3
2	14.2
3	13.9
4	6.6
5	3.5
6	1.7
7	0.7
8	0.3
Average	1.55

by 36%. Slightly over half the sample (51%) experienced between 1 and 3 events, and 6% experienced 5 or more events.

MULTILEVEL MODEL OF COUNTS OF EVENTS WITH INJURY-PRODUCING POTENTIAL

A Poisson regression model was constructed for the outcome event of injury-producing potential, first using individual-level factors alone. Then, neighborhood-level characteristics were added to the model with potential interaction terms and appropriate random variation elements. Final models were derived using a backward stepwise procedure based on likelihood calculations.

Table V summarizes the parameter estimates of the multilevel Poisson regression model. Each estimate reflects the change in the log of the number of events per

TABLE V Multilevel Poisson Regression Model Coefficients for Individual and Neighborhood Variables

Term	Parameter Estimate	(Standard Error)
Intercept	0.45	(0.48)
Individual-level variables		
Employed	−0.13	(0.10)
Longer length of residence	−0.02	(0.04)
Female gender of respondent	−0.04	(0.11)
Older age of the respondent*	−0.06	(0.03)
Census tract–level variables		
Per capita income (per 1,000 dollars)	0.01	(0.04)
Housing violations (per 100 households)*	0.02	(0.01)
Crime rate (per 100 individuals)	0.01	(0.01)

*$P < .05$.

unit change in the independent variable. The reference child's injury frequency, denoted by the value of the intercept, is for a child living in a home in which the adult respondent was unemployed, male, younger than 20 years, and had lived in the home for less than 2 years. The reference child's neighborhood had zero per capita income, zero crime rate, and zero housing violations. The reference child's injury frequency was $e^{0.45}$, or 1.57 injuries, which is nearly identical to the average injury frequency (1.55 injuries) noted in Table IV.

Among the four individual-level factors, age of the respondent was the only significant predictor of injury-event frequency ($P < .05$). For each increase in age interval (see Table I), there is an expected decrease of $e^{-0.06}$, or 0.9 fewer injury events. Thus, children in households with older respondents are predicted to have a lower number of events with injury-producing potential after adjusting for employment status, length of residence in the home, gender, and neighborhood characteristics.

Among the three census tract–level variables, the rate of housing violations was a significant predictor of injury events ($P < .05$). As this variable is expressed as number of violations per 100 households, a 1% increase represents an increase of $e^{0.02}$ or 1.0 injury events. Children living in census tracts with poor housing tended to have a higher number of injury events after adjusting for per capita income, crime rate, and individual-level variables.

In regard to the third study objective, no interaction terms between individual and census tract–level variables were found to be significant. The final model does not include these terms.

DISCUSSION

This study utilized a survey of households in 18 low-income census tracts to estimate rates of events with injury-producing potential affecting young children and associated risk factors at the individual level, as well as the community level. A multilevel Poisson regression model was constructed that allowed for identifying significant predictors of frequency of events with injury-producing potential.

While all the census tracts included in this sample are considered low income, substantial variability for housing and crime indicators for these neighborhoods was observed. Interestingly, housing violations and crime rates did not correspond directly with average income. These economically deprived communities represent a heterogeneous collection of contexts, some with poor housing and high crime rates, others with better housing and low crime rates, and many with mixed levels of housing quality and crime.

In addition to the variation seen among indicators of census tract impoverishment, we observed variation in the prevalence of various events with injury-producing potential across contexts. In some census tracts, many children experienced falls within the home. In other census tracts, falls were less common, while getting hold of dangerous items was more common.

A few potential biases may alter the validity and generalizability of these findings. These events with injury-producing potential are based on the survey respondent report, and the respondent may or may not have been the child's primary caretaker. Another potential bias is related to the enumeration of children within households and injury prevalence. This study asked if any child under the age of 5 years living in the household experienced one of the 12 events with injury-producing potential. In conducting the analyses, one child per household was chosen to represent the household in cases for which more than one child was reported to have experienced the event. While this did not alter the prevalence of the events greatly, the denominator reflects a proportion of households and not a proportion of young children living in these census tracts. While 65% of households in this study reported having a young child experience an event with injury-producing potential, this does not imply that 65% of children in these census tracts experienced such events. Nevertheless, that almost two-thirds of households with young children had such events in a 1-month period underscores the need for injury prevention interventions. Information regarding the number of uninjured children living in each household might have provided a clearer sense of the injury prevalence. However, the purpose of the analysis was not to describe precisely the prevalence of injury in this population, but rather to begin to articulate a community perspective of injury risk and hazardous environments. There is no comparable data on the prevalence of injury-producing events in middle-class and upper-class communities. Inferences and comparisons between income strata are not possible for this reason. While it would be useful to pursue this question in future research, studying determinants of injury risk within low-income urban areas is important in its own right given the high rates of injury mortality and morbidity among children in these environments.[14,18–20]

A multilevel Poisson regression model indicates that survey respondents of older age reported significantly fewer child injury events, most of which occurred within the home, after adjusting for other individual and census tract characteristics. If one assumes that a majority of the respondents (i.e., parents, grandparents) are primary caregivers to the children, then the age of the caregiver is related significantly to injury event frequency, with younger parents possibly presenting a higher risk to the children. This would be consistent with other studies of family characteristics and child injury risk.[16] The multilevel model also indicates that the quality of housing within a census tract is a significant predictor of injury event frequency. Children living in census tracts with many housing violations are more likely to incur a greater number of injury events after adjusting for per capita income and crime rate. This is not simply an ecological analysis of individual houses, however. The community with poor housing presents challenges to the child who lives in a structurally dangerous home, but also presents challenges to other children who play in or near dilapidated houses. The community with poor housing may have higher injury event prevalence because a greater proportion of the total environment is in need of repair, beginning first and foremost with the houses.

Community characteristics are being recognized increasingly as important determinants of health and social outcomes.[21,22] Elements of neighborhoods such as housing, crime, and economic networks contribute to a social milieu in which individuals must face health and social risks. An earlier study of parents in Baltimore found that living in substandard housing (measured at the individual level) was a significant barrier to reducing children's exposure to risk by childproofing.[6] As the present study demonstrates, substandard housing at the community level significantly increases children's injury risk. Moreover, the definition of "substandard" used by the city includes the presence of quite severe physical hazard violations, which would suggest that the proportion of truly hazardous housing conditions may be greater than our figures suggest. These findings suggest that, to reduce the prevalence of child household injuries in low-income urban settings, a community-level approach to improving the quality of environments, especially the community's housing, could help. Programs that ignore the role of housing quality in injury risk may reduce their potential impact substantially. Future research efforts should elucidate the detailed mechanisms underlying the associations found in this study. Understanding the relationship among community housing codes, policies, and injury risk deserves further attention.

APPENDIX

This appendix explains the rationale for use of the multilevel statistical methods for our analysis of the effect of neighborhood and individual factors on the risk of experiencing events with injury-producing potential. The conceptual basis for the two-level model is that the effect (e.g., the β coefficient in regression) of individual-level variables, such as age and employment status of respondent, differs between the level 2 units (in our case, between the census tracts). In contrast to ecological analyses, which simply compare aggregate values of different factors, multilevel models simultaneously account for individual factors and the emergent properties of communities comprised of many individuals.[23]

As an example, we might be interested in building a simple two-level model with the independent variables age, employment, and per capita income; we could write two sets of equations (see below). One equation would describe how the individual-level variables (level 1) are associated with the outcome, the number of events with injury-producing potential.

Level 1 $\quad g[\text{Injury}_i] = \beta_{oj} + \beta_{1j}\ \text{age} + \beta_{2j}\text{Employment}$

The second set of equations would describe how the community-level variables are associated directly with the number of events with injury-producing potential (level 2 intercept) and whether and how the community-level variables, per capita income in this case, interact with the age and gender in their association with injury (level 2 age and level 2 employment). These level 2 models would be written as

Level 2 intercept	$g[\beta_{0j}] = \eta_{00} + \eta_{01}\text{Income}_j + u_{oj}$
Level 2 age	$g[\beta_{1j}] = \eta_{10} + \eta_{11}\text{Income}_j + u_{1j}$
Level 2 employment	$g[\beta_{2j}] = \eta_{20} + \eta_{21}\text{Income}_j + u_{2j}$

In all of the equations above, the index j represents communities and can take on values from 1 to 29, and i represents individuals and can take on values from 1 to n^{ij}, the size of community j.

MLn actually estimates all the β's and the η's simultaneously. The separate models above would fit in MLn as follows:

$$\begin{aligned} g[\text{Injury}_{ij}] = {} & \eta_{00} + \eta_{10} + \eta_{20} + \eta_{01}\text{Income}_{ij} + \eta_{10}(\text{Age})_{ij} + \eta_{11}\text{Income}_j(\text{Age})_{ij} \\ & + \eta_{20}(\text{Employment})_{ij} + \eta_{21}\text{Income}_j(\text{Empl})_{ij} + u_{0j} + u_{1j}(\text{Age})_{ij} \\ & + u_{2j}(\text{Empl})_{ij} \end{aligned}$$

Unlike traditional software, which assumes that residual components of a regression are centered on zero with homoscedasticity, MLn estimates the values of residual/random components. In the equations above, $g[\beta_{0j}]$, $g[\beta_{1j}]$, and $g[\beta_{2j}]$ are the random components of the model. Use of MLn, or a method that allows for the multiple random components, is necessary for multilevel models. Using MLn, it is possible to assess not only the direct effects of the neighborhood-level factors, but also the moderating effects of the neighborhood factors on the individual-level variables. In the equations above, $\eta_{01}\text{Income}_j$ represents the direct effect of income on the counts of events with injury-producing potential, and $\eta_{11}\text{Income}_j$-$(\text{Age})_{ij}$ represents the moderating effect of income on the relation between age of the respondent and the counts of events with injury-producing potential. For example, we could determine whether the protective effect of being an older respondent was similar in neighborhoods of high or low income or whether the protective effect was more prominent in neighborhoods with different levels of income.

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